Spine and Spinal Cord Injuries After Falls From Tree Stands During the Wisconsin Deer Hunting Season

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ABSTRACT

Background: Deer hunting is popular in much of the United States. In Wisconsin, use of tree stands for hunting is common. Spine surgeons at a Level 1 Trauma Center observed a high incidence of spine and spinal cord injury due to falls from tree stands while hunting. This study's purpose is to systematically characterize and classify those injuries.

Methods: We reviewed the University of Wisconsin Hospital and Clinics' trauma database for tree stand-related injuries from 1999 to 2013. We collected and analyzed data pertaining to hunters' demographics, comorbidities, type and mechanism of injury, injury severity, and management.

Results: We identified 117 patients evaluated after a tree stand fall. Sixty-five (ages 16-76) suffered spine fractures that occurred at all levels, from occipital condyle to sacrum, with thoracolumbar compression and burst fractures being most common. Fractures occurred in the following locations: cranio-cervical junction (8.7%), cervical spine (7.6%), cervical-thoracic junction (6.5%), thoracic spine (32.6%), thoracolumbar junction (33.7%), and lumbar spine (10.9%). Twenty-one patients (32%) experienced a single spinal fracture; 44 patients (68%) suffered multiple spinal fractures. Twenty-five patients (38%) required surgical fixation; 19 patients experienced loss of neurologic function: 5 complete spinal cord injuries (SCI), 5 incomplete SCI, 2 central cord syndromes, and 8 radiculopathies. Two mortalities, both of cardiopulmonary etiology, were noted—one in a patient without a spine fracture and the other in a patient with a complete spinal cord injury at T4.

Conclusions: The majority of spine fractures are treated nonoperatively. However, enough patients require surgical intervention that consultation with a neurosurgical or orthopedic spine surgeon is prudent. It is more common to have multiple spine fractures from a tree stand fall, therefore, it is recommended that if 1 fracture is identified the entire spine be evaluated for additional fractures. For safety, it is recommended that hunters wear and use safety harnesses appropriately. Additionally, keeping the height of the tree stand at 10 feet or less is associated with a lower likelihood of spinal cord injury. Further study is needed to determine additional interventions such as education that might reduce the injury frequency in this population.

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BACKGROUND

Wisconsin supports a widely popular hunting program, with a 9-day firearm deer season in November and a 5-month bow and arrow season extending from September to January. Recreational hunting in Wisconsin dates back to 1851, with the first documented deer season. According to the Wisconsin Department of Natural Resources, nearly 500,000 Wisconsin residents have obtained deer hunter licenses per year for the last 15 years. Despite hunting regulations written into law, 12 deaths related to firearm injury occurred during the hunting season of 1900.[1] The most recent analysis of Wisconsin's hunting trauma included review of the hunting accidents seen at the University of Wisconsin Hospital from 1999 through 2004. These authors reported 24 hunters requiring inpatient treatment, including 8 patients injured by firearm accident and 16 patients who suffered from tree stand falls.[2] This series included 6 head or spine injuries and 2 fatalities.

Our study highlights the importance of tree stand falls as a key contributor to the overall morbidity of recreational hunting in Wisconsin. Similar studies reviewing hunter injury, trauma, and disease have shown the significant morbidity stemming from spinal cord injuries secondary to falls from a significant height.[3-9] We characterize the spinal injuries and treatment modality pursued after a fall from a tree stand.

METHODS

This is a retrospective chart review, with focus on spine and spinal cord injuries secondary to tree stand falls during the Wisconsin

hunting season. The University of Wisconsin Hospital and Clinics (UWHC) trauma registry database was used to identify patients whose injuries were related to falling from a tree stand. Beginning in 1999, the UWHC trauma database classified "tree stand fall" as a specific chief complaint. All such events between January 1, 1999 and February 19, 2013 were reviewed, and all charts with this chief complaint were included in the study. There were no exclusion criteria. Institutional Review Board exemption was granted for this study as a medical records review.

Charts were reviewed via the electronic medical record (EMR). A database was created for information abstraction and documentation with study identification numbers used to protect patient anonymity. The following data points were entered, when available, for each patient: sex, age, body mass index (BMI), diagnosis of diabetes mellitus, heart disease, coagulopathy (intrinsic or secondary to medical therapy), history of tobacco use, admission Glascow Coma Scale score, use of safety harness, height of fall, mechanism of injury (circumstance surrounding fall, if known), involvement of alcohol or other drugs, total list of traumatic injuries, spinal fracture level and type, presence of neurologic dysfunction, surgical interventions, hospital length of stay, intensive care unit (ICU) length of stay, and inpatient complications. Injury severity scores were calculated for each patient. Data abstraction and score calculation was completed by 1 researcher to ensure consistency. Information regarding hunters' years of experience and the type of tree stand in use was not found for any patient in the EMR and, therefore, was not included.

Further analysis of spine and spinal cord injuries included classification of the fracture type and location, details of the treatment pursued, and overall hospital course. Spinal fractures were identified and categorized into the following types, as fracture pattern affects stability and management: fractures of the posterior elements, including the transverse processes, spinous processes, or lamina; facet fractures; compression fractures; burst fractures; Chance (3-column distraction) fractures; and fracture dislocations. Fracture location was identified as cranio-cervical junction (including the occipital condyles, C1, and C2), subaxial cervical spine (C2-3 disc to C6-7 disc space), cervicothoracic junction (C7-T1), thoracic spine (T1-T9-10 disc), thoracolumbar spine (T10-L1-2 disc space), lumbar spine (L2-L5-S1 disc), or sacrum. Statistical analyses were performed between groups using unpaired 2-tailed *t*-tests.

RESULTS

One hundred seventeen patients were identified as suffering trauma related to falls from a tree stand. Of these patients, 65 (55%) were identified with 1 or more spinal fractures. These patients were predominantly male (63 of the 65), with an average age of 45 (range 16-76). Three had history of diabetes, 19 had heart disease, and 5 reported daily aspirin, clopidogrel, or warfarin. Fourteen patients endorsed chronic tobacco use (unknown history for 10 patients), and 7 admitted to using alcohol the day of their accident (negative blood alcohol levels for 39 patients, and unknown use in 19). Only 4 patients (3.4%) reported use of a safety harness, and also reported that they believed the harness to have malfunctioned during the fall.

Trauma records documented any known events surrounding the fall, as well as reported estimated fall height. Patients suffering spinal fractures were noted to have landed on their head or neck in 5 cases, their buttocks or back in 19 cases, or the chest or side in 6 cases. Eleven patients were thought to have experienced transient loss of consciousness after their fall. Patients reported having lost consciousness prior to their fall in 4 cases; 5 additional patients fell asleep and subsequently fell from their stands. Four patients reported mechanical failure of their stand, such as the tree branch breaking or collapse of the stand. Four patients reported failure of their safety harness during their fall. Six patients noted they were performing stand maintenance at the time of their fall, while 2 patients noted they fell in the process of entering or exiting their stand. The cause of fall is unknown for 40 patients.

Fall height ranged from 6 feet to over 30 feet, with the majority of falls occurring from a height of 11 to 20 feet. Falls from less than 10 feet were associated with less severe neurologic injury (focal radiculopathy or no neurological deficit). However, falls from any height greater than 11 feet were seen in conjunction with more severe neurologic injuries, including radiculopathy, central cord syndrome, and spinal cord injury.

Spine fractures commonly occurred in multiples, with 68% (44 of 65) of patients experiencing 2 or more spine fractures. While 1 patient was noted to have as many as 9 spinal fractures, most patients suffered from 2 or 3 fractures. Compression fractures and fractures of the posterior elements (lamina, spinous process, transverse processes) were the most commonly seen fractures across multiple levels. Only 5 patients experienced a single level compression fracture, while 11 patients experienced multiple levels of compression fractures. No patient was noted to have a single level of posterior element fracture, while 8 patients suffered multiple level posterior element fractures. Compression fractures were seen in conjunction with a higher-energy injury such as a burst fracture, Chance fracture, or fracture dislocation in 18 patients. The incidence of fractures in isolation versus combination are displayed in Figure 1.

In 35 cases, patients suffering spinal fractures had additional injuries including rib fractures, pneumothoraces, extremity and pelvic fractures, and organ and closed head injury. Patients' Injury Severity Scores (ISS) were calculated with consideration for all documented traumatic injuries.[10] The ISS ranged from 4 to 43 for all patients with spinal fractures, with an average of 17. For patients whose spinal injury required surgical intervention (25 of 65 patients), the ISS range was 9 to 42 and the average was 23. The difference in ISS for patients with spinal fractures compared

to those with no spinal injury was statistically significant; the spinal fracture group averaged an ISS of 17 while the group without spinal fracture averaged only 11 (P = 0.0006; CI, 2.33 to 8.32). Patients who did not sustain any injury to the spine, either fracture or neurological deficit, reportedly were hunting from stands at an average height of 15.4 feet. Patients who suffered a spine injury fell from an average height of 18.3 feet, which nears statistical significance (P=0.0523; CI, -5.7 to 0.0289). Two mortalities were noted in our series: one secondary to pulmonary embolus and cardiac arrest, the other due to respiratory failure following massive blunt chest trauma in conjunction with a complete spinal cord injury at the level of T4.

Neurologic dysfunction was noted in 19 of the 65 patients (29%) with spinal fractures. Five patients suffered complete spinal cord injury (SCI), and an additional 5 patients experienced an incomplete spinal cord injury. For 9 of the 10 patients, SCI was seen in conjunction with burst or fracture dislocations; 1 patient experienced incomplete SCI due to a cervical facet fracture in the setting of ankylosing spondylitis. Central cord syndrome was documented in 2 patients: one with no associated cervical spine bony injury, one with C2 facet and C5-7 posterior element fractures. Eight patients experienced focal radiculopathies that were caused by compression or facet fractures in 71% of the cases.

Treatment of the spinal fractures and neurological injury varied greatly. Twenty-five patients (38%) underwent surgical intervention for their fractures. Forty patients underwent conservative management: 32 patients (49%) were braced and 8 patients (12%) required no treatment. Patients who suffered neurological deficit were more likely to undergo a surgical intervention (P = 0.0001; CI, -0.83 to -0.39) for decompression of the neural elements, stabilization of the fracture, or both. Four patients who were originally braced required surgery on a delayed basis for instability documented on follow-up imaging (Figure 2). These patients had experienced a variety of fractures including cervical facet fractures, thoracic fracture dislocation, and fracture through a cervical anterior osteophyte.

Figure 1. Patients With Single Versus Multiple Fractures, N=117

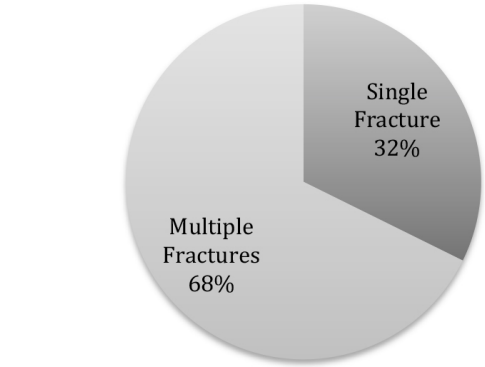
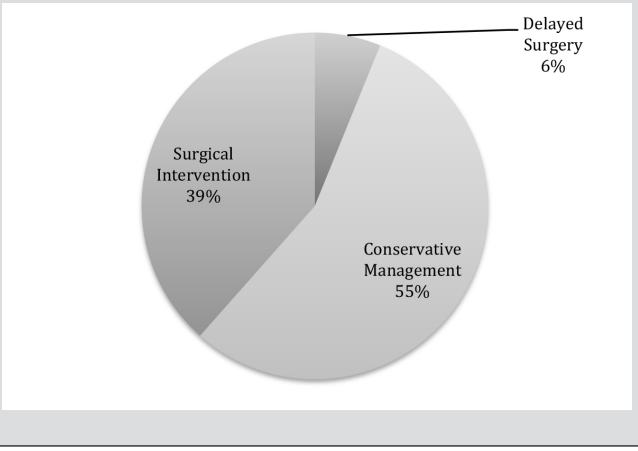


Figure 2. Management of Spinal Injury



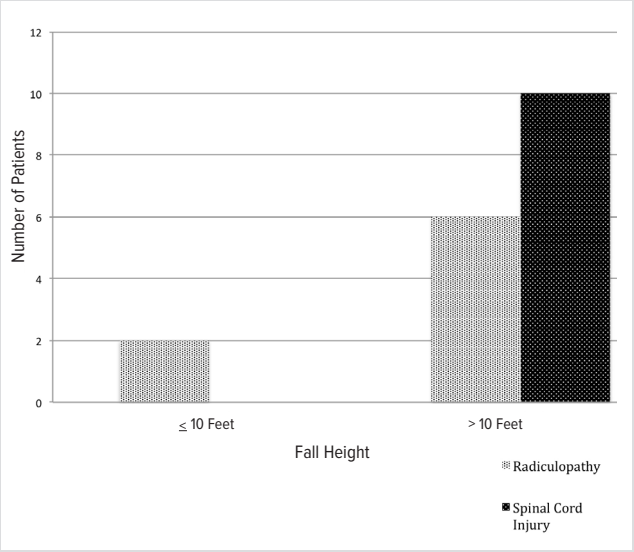
DISCUSSION

Falls from tree stands are multifactorial in nature. Our patient series reflected a variety of fall etiologies, including both syncope and falling asleep while hunting. Other similar studies have found a wide range of contributing factors, including fatigue, exposure, mechanical falls while entering and exiting the stand, failure to wear a safety harness, use of drugs and alcohol, use of hunter-constructed tree stands and inexperience with a certain stand.[3-5,7,9] Additionally, several studies reported significant delays from the time of injury to presentation in the emergency department, which increases the risk for complications such as hypothermia and negates immediate intervention for spinal cord injury.[4,11] Even with use of safety restraints, the recommended full body harnesses are still a potential cause for injury if the hunter must remain suspended for more than 30 minutes.[2]

Our results reflect minimal use of harnesses, as well as cases of improper use or harness malfunction. Notably, however, a study conducted in Louisiana found a significant decrease in the incidence of tree stand falls following a public information campaign that included pamphlets detailing the risk of disability distributed to hunting clubs and sport and hunting supply stores. For 3 years thereafter, the state had zero reported spinal cord injuries associated with falls from tree stands.[12] This supports the positive effects that education, awareness, and use of safety harnesses have on lowering the rate of tree stand falls and associated injuries.

Previous studies on the dangers of hunting with tree stands also found serious morbidity among this patient population. From Ohio, more significant injuries were seen in those who had fallen from a tree stand than from hunters suffering an accidental gunshot wound.[3] Several groups have reported similar rates of spine fractures following tree stand falls: 52% by Metz et al,[6] 59% by Crockett et al,[3] and 36% by Gates et al.[5] The overall injury severity was significantly worsened when spinal injury was experienced at the time

Figure 3. Neurological Injury Associated With Tree Stand Height



of the fall, as evidenced by the strong difference in injury severity scores for the patients with spinal fracture versus without (P = 0.0006).

Unfortunately, our data analysis did not identify any modifiable risk factor associated with patients suffering spinal fractures versus those who did not. However, the majority of patients who suffered any spinal fracture actually experienced multiple levels of spinal injury. If 1 spine fracture is noted on trauma evaluation, the remainder of the spine should also be imaged. Interestingly, our series of 117 patients revealed only 4 patients who suffered from closed head injury, making this traumatic patient population unique from those experiencing trauma due to motor vehicle accidents.

Tree stand falls clearly carry a significant risk of spine and spinal cord injury. Based on this study, 56% of the patients (65/117) who fall from tree stands sustain a spine fracture, and 29% of those with spine fractures (19/65) sustain a neurologic injury. Patients with neurological deficit were significantly more likely to undergo surgical intervention for their spinal injury (P = 0.0001) for decompression of the affected neural elements, stabilization of the fractured level, or both. Therefore, any patient with suspected neurological injury following fall from tree stand should be transferred to a facility with a spine surgeon. Eight percent (10 of 117) of all patients falling from tree stands suffered a spinal cord injury in our series; 100% of these patients were noted to have fallen from tree stands at a height of greater than 10 feet (Figure 3).

The morbidity following injuries involving the neurological system is significant, leaving patients with potentially lifelong disabilities. Thus, prevention measures should not only focus on reducing the frequency of falls from tree stands, but also reducing the likelihood that patients experience neurological deficit from the injuries they sustain. The most effective management would be primary prevention of tree stand falls. This could include safety classes, videos, and educational literature specific to tree stand use, as well as general health education and physical examination to ensure cardiovascular wellness prior to the physical exertion of hunting. In addition, hunters should be counseled on the importance of safety harnesses and how to use them properly. Hunters must also be made aware the dangers of hunting while either sick (as dehydration can lead to syncope), cardiovascularly deconditioned, or under the influence of drugs or alcohol. Additionally, given the increased incidence of spinal cord injury with the use of tree stands at greater than 10 feet in this study, suggesting use of tree stands at 10 feet or less could be considered.

According to the Wisconsin Department of Natural Resources,[13] current Wisconsin law requires anyone born after January 1, 1973 to complete hunter education coursework prior to obtaining a state hunting license. The Wisconsin Hunter Education website provides study guides for both firearm[14] and bow hunting,[15] including safety instructions for use of tree stands and safety harnesses. The importance of hunter safety education should be emphasized with all patients who engage in hunting sports.

Once hunters suffer from a tree stand fall, treatment must be optimized from the time of the emergency response call. Training hunters and first responders to recognize the importance of meticulous spine precautions at the scene and during extraction and transport from the accident site is critical. Additionally, these patients should be transferred rapidly to a trauma center with neurosurgical or orthopedic spine capabilities, and attempts should be made to maintain cord perfusion en route. Early contact from first responders to the accepting hospital should be made to ensure spine and trauma surgeons are awaiting the patient's arrival. The surgeon may even guide spinal cord management by phone. Treatment at a facility such as a Level 1 trauma center is ideal for the complex care required by these patients. Many patients will have concurrent injuries, and some surgical interventions may also require assistance from general or vascular surgeons.

CONCLUSION

Injuries sustained from tree stand falls are a significant source of spinal injury and neurological dysfunction, leading to lifelong morbidity. The majority of spine fractures are treated nonoperatively; however, enough patients require surgical intervention that consultation with a neurosurgical or orthopedic spine surgeon is prudent. Because it is more common to have multiple spine fractures from a tree stand fall, evaluating the entire spine for additional fractures is recommended if one fracture is identified.

The primary treatment of tree stand injuries is prevention. Educational initiatives published previously demonstrates that increased public awareness of the risks associated with hunting and tree stand use led to fewer tree stand falls associated with spinal cord injury.[12] It is our hope to lower the rate of tree stand falls in Wisconsin through increased patient education and pub-

lic awareness, and to see a secondary decrease in the number of traumatic spinal injuries in hunters. Physicians participating in the care of this patient population can help by promoting hunter education; the routine, appropriate use of safety harnesses; and the fabrication of tree stands at 10 feet high or less.

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